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Abstract

The detailed geological survey of the Upper Member of the Eocene Pondaung Formation in the Paukkaung area (Myaing Township, Magway Division, central Myanmar) has been carried out in order to clarify the stratigraphic relationship among the localities of fossil vertebrates (Pk1, Pk2, Pk3, Pk4, Pk5, Pk8, Pk9 and Pk12). Most of the fossil-bearing localities (Pk1, Pk2, Pk3, Pk4, Pk5 and Pk8) belong to a single claystone sequence of the Pondaung Formation, named the Ayoedawpon Taung Claystone, which directly lies upon the widely traceable Ayoedawpon Taung Sandstone. Another two localities, Pk9 and Pk12 lie on the horizons underlying and overlying the Ayoedawpon Taung Claystone, respectively.

Zusammenfassung

Die geologische Untersuchungen des oberen Gliedes der eozänen Pondaung-Formation im Paukkaung-Gebiet (Gemeinde Myaing, Bezirk Magway, Zentral-Myanmar) wurden durchgeführt, um die stratigraphischen Beziehungen zwischen den fossile Wirbeltiere führenden Aufschlüssen (Pk1, Pk2, Pk3, Pk4, Pk5, Pk8, Pk9 und Pk12) zu klären. Die meisten der Wirbeltiere führenden Aufschlüsse, d.h. Pk1, Pk2, Pk3, Pk4, Pk5 und Pk8, gehören zu einer Tonstein-Abfolge (hier als Ayoedawpon-Taung-Tonstein bezeichnet), die unmittelbar über dem weitflächig verfolgbaren Ayoedawpon-Taung-Sandstein lagert. Zwei

weitere Aufschlüsse, Pk9 und Pk12, befinden sich innerhalb der Horizonte im Liegenden bzw. im Hangenden des Ayoedawpon-Taung-Tonsteins.

Introduction

The Eocene Pondaung Formation, distributed widely in central Myanmar, has been famous for yielding such fossil vertebrates as primates, creodonts, carnivorans, rodents, artiodactyls, perissodactyls, turtles, crocodiles, lizards, fishes and birds (e.g., Pilgrim and Cotter, 1916; Colbert, 1937; Tsubamoto *et al.*, 2000, 2006). Several outcrops (named in Burmese "Kyitchaung") that are scattered in the area around Paukkaung village (Myaing Township, Magway Division, Myanmar; Figure 1) yield these fossils abundantly compared with other areas. Because these fossil-bearing outcrops are separated with each other in a distance of several hundred meters, the stratigraphic relationships between outcrops could not be understood directly. We, therefore, have carried out detailed geological survey in the area in order to prove the stratigraphic relationships among the fossil-bearing outcrops (Kyoto University localities, Pk with number). In this report, we show the stratigraphic relationship among the fossil vertebrate localities.

Geology of the Paukkaung area

The Pondaung area, which encloses our study area (the Paukkaung area) is situated in the Inner-Burman Tertiary Basin of the four geotectonic provinces of Myanmar: from east to west, the Sino-Burman Ranges, the Inner-Burman Tertiary Basin, the Indo-Burman Ranges and the Arakan Costal Area (Chhibber, 1934; Bender, 1983). In the Inner-Burman Tertiary Basin, the Cenozoic fluviatile to shallow marine sediments are mainly distributed. The Minbu Basin in the Inner-Burman Tertiary Basin is characterised by the synclinal structure (the Salin Syncline), of which north margin is affected by the Neogene uplifting around the latitude 22°N (Bender, 1983). The Paukkaung area lies near this 22°N uplifting area. Around the Paukkaung area, the Eocene Pondaung Formation, the Eocene Yaw Formation and the Miocene to lower Quaternary Irrawaddy Group are distributed.

The Pondaung Formation in the Pakkaung and nearby areas is subdivided into the Upper and Lower Members (Aye Ko Aung, 1999). In the Paukkaung area, the Upper Member of the Eocene Pondaung Formation is widely distributed. Its geologic age has been discussed using micropalaeontologic, radiometric and stratigraphic evidences (see Tsubamoto *et al.*, 2006 in this volume for a review) in detail, and it is concluded as late Bartonian age (late Middle Eocene). However, the studies of the decisive leading fossils (benthic foraminifera) from the overlying Yaw Formation are classic (Stamp, 1922; Rao, 1942) or without figures (Bender, 1983), so that the further studies will be needed with modern means for the age determination of the Yaw Formation, which constrains the youngest age of the Pondaung Formation.

The Upper Member of the Pondaung Formation in the Paukkaung area is composed mainly of sandstone, siltstone and silty claystone. Minor amounts of gritty to pebbly

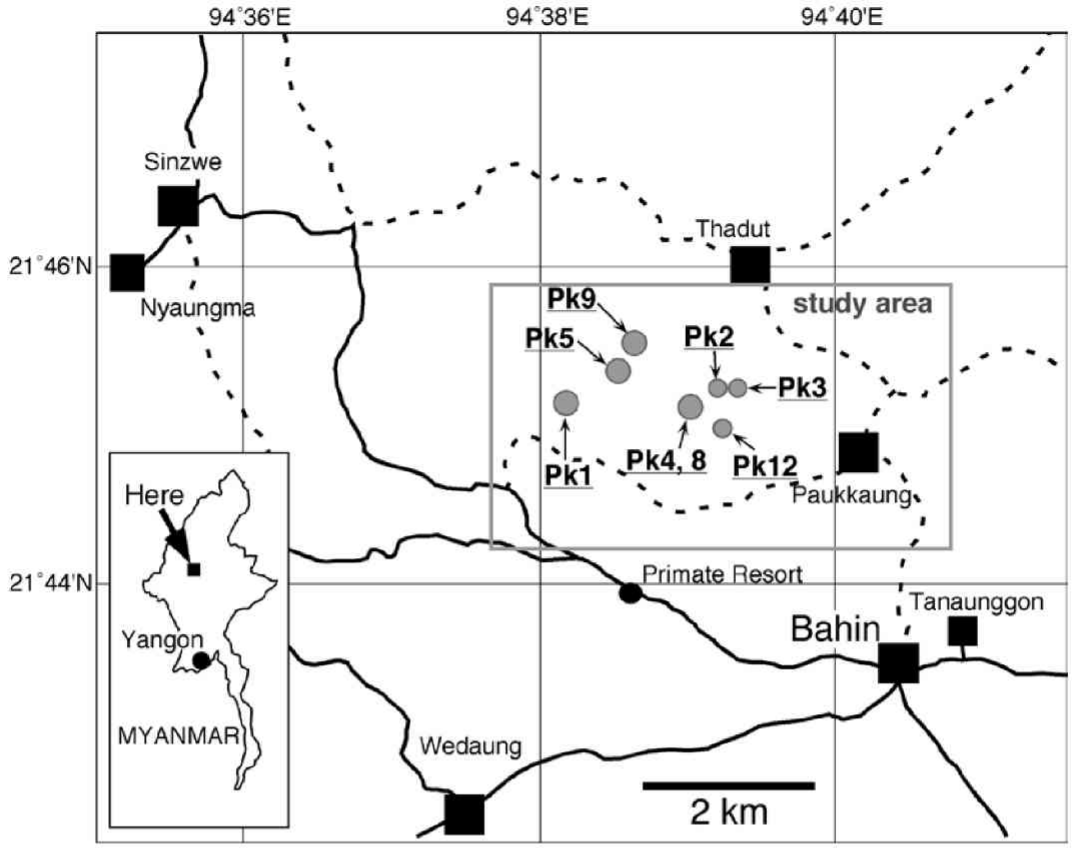

Figure 1. Location map of the Paukkaung area, central Myanmar. Grey areas indicate the fossil vertebrate localities (Kyoto University localities; Pk with number).

sandstone, conglomerate and acidic tuff are intercalated within the member. Bedding planes between these lithologies are nearly horizontal to 15° dipping southwards. Trough and planar-type cross stratifications are commonly found within sandstone beds. Minor vertical faults are sparsely distributed, their vertical offsets range from ca. 1 m to several meters.

Lithostratigraphy

The lithologic column of the Upper Member of the Pondaung Formation in the Paukkaung area is shown in Figure 2. The thickness of the Upper Member amounts to 270 to 280 m. At the basal horizon of the Upper Member a conglomerate to gritty sandstone bed occurs. Above the conglomeratic bed, the claystone-dominant sequences develope with intercalations of three sandstone beds between Pk9 and Pk12 horizons (Figure 2), which are subhorizontally traceable in the study area. Fossil vertebrates have been found mostly from the claystone-dominant sequences in the lower part of the Upper Member (Figure 2). In the middle to upper horizons of the Upper Member in the study area, the alternation beds of claystone and sandstone and/or thick sandstone sequences are mainly distributed. Little fossil vertebrates occur in the middle and upper horizons.

Stratigraphic positions of the fossil localities

The fossil vertebrate localities (Kyoto University localities; for the GPS data, see Tsubamoto *et al.*, 2006 in this volume) of the Paukkaung area (Pk1, Pk2, Pk3, Pk4, Pk5, Pk8, Pk9 and Pk12) are stratigraphically subdivided into the three horizons.

Kyoto University localities Pk1, Pk2, Pk3, Pk4, Pk5 and Pk8

Claystone outcrops of the localities Pk1, Pk2, Pk3, Pk4, Pk5 and Pk8 belong to a single claystone sequence, which is here named the Ayoedawpon Taung Claystone. Its colour is mainly reddish brown, purple, whitish grey or greyish yellow. Whitish to pinkish white tuff layers are occasionally intercalated to the lower part of the Ayoedawpon Taung Claystone. The fission-track age of zircon grains from the tuff layer at Pk1 was measured as 37.2 ± 1.3 Ma (Tsubamoto *et al.*, 2002). The thickness of the Ayoedawpon Taung Claystone is variable from 8 m at Pk1 to 20 m at Pk3. The Ayoedawpon Taung Claystone overlies directly a widely traceable sandstone bed, here named the Ayoedawpon Taung Sandstone. The primate fossils such as *Amphipithecus*, *Pondaungia*, *Myanmarpithecus* and cf. *Eosimias* have so far been discovered from the Ayoedawpon Taung Claystone (e.g., Ciochon *et al.*, 2001; Gebo *et al.*, 2002; Gunnell *et al.*, 2002; Ciochon and Gunnell, 2002; Takai *et al.*, 2003, 2005; Egi *et al.*, 2004; Shigehara and Takai, 2004). Soe Thura Tun (2004) also concludes that the localities Pk1, Pk2, Pk3 and Pk5 belong to a same horizon based on an image interpretation from air photographs.

Kyoto University localities Pk9

The claystone outcrop at the Pk9 belongs to the Nyaungpinle Claystone which is stratigraphically located on a lower horizon than the Ayoedawpon Taung Claystone. The Nyaungpinle Claystone is overlain by a pair of sandstone-claystone beds that are overlain by the Ayoedawpon Taung Sandstone. Although *Anthracotherium* and amynodontids occurred (Tsubamoto *et al.*, 2006 in this volume), no fossil primates have hitherto been found from Pk9.

Kyoto University localities Pk12

The claystone outcrop of Pk12 overlies directly the sandstone bed that is underlain by the Ayoedawpon Taung Claystone. The locality Pk12 is, therefore, located on the higher horizon than the Ayoedawpon Taung Claystone. The primate fossil of *Myanmarpithecus* was found from Pk12 and described by Egi *et al.* (2006).

Concluding remarks

(1) The Upper Member of the Pondaung Formation is widely distributed in the Paukkaung area due to its geologic structure of gentle dip (horizontal to 15°).

(2) The Upper Member of the Pondaung Formation in the Paukkaung area consists of

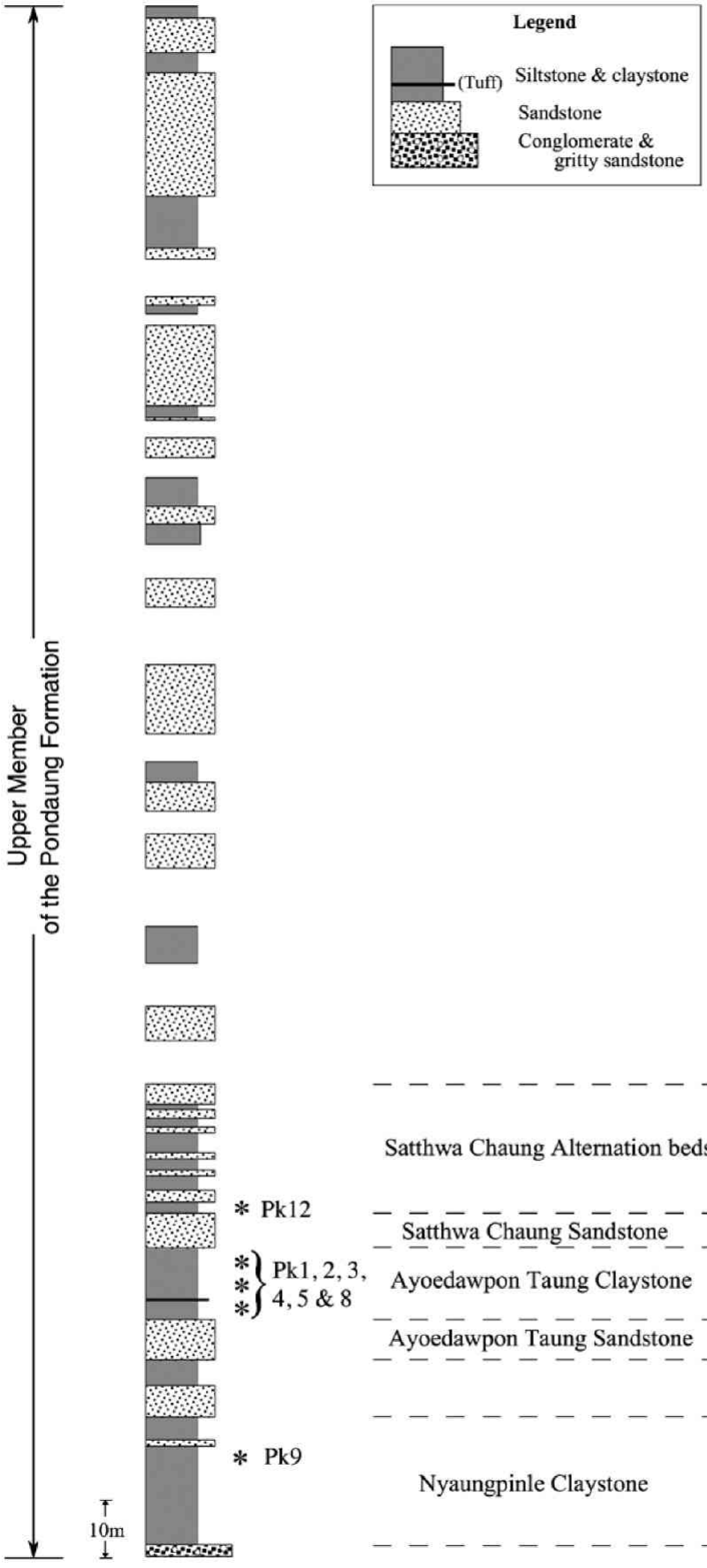

Figure 2. Lithologic column of the Upper Member of the Pondaung Formation in the Paukkaung area, showing the stratigraphic positions of the fossil vertebrate localities.

claystone and sandstone with small amount of gritty to pebbly sandstone, conglomerate and acidic tuff.

(3) The total thickness of the Upper Member of the Pondaung Formation in the Paukkaung area amounts to approximately 270 to 280 m.

(4) We conclude with our detailed data that the fossil vertebrates are discovered mainly from the lower part of the Upper Member, as has been already mentioned by Colbert (1938) and Aye Ko Aung (1999, 2004). Their occurrence is generally constricted to the claystone strata, but rarely they present in a fine-grained sandstone within a claystone sequence.

(5) The primate fossils such as *Amphipithecus*, *Pondaungia*, *Myanmarpithecus* and cf. *Eosimias* have so far been discovered exclusively from the single claystone sequence (Ayoedawpon Taung Claystone; localities Pk1, Pk2, Pk3, Pk4, Pk5 and Pk8). One exception is an occurrence of *Myanmarpithecus* in the claystone of the locality Pk12 that lies at the horizon slightly higher than the Ayoedawpon Taung Claystone.

(6) The thickness of the Ayoedawpon Taung Claystone varies from 8 m to 20 m. Whitish tuff layers are intercalated within the lower part of the Ayoedawpon Taung Claystone.

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